Sustainability of the agri-food system: Strategies and Performances

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The Use of Environmental, Economic and Social Indicators as Decision Support for the Advancement of Farms towards Sustainability

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Abstract
Modern agricultural activities require a increasingly level of balance between the productive standards necessary for the food supply and the farms profitability and an equally sustainable social and environmental impact on today's rural systems. This work aims to create a multi-level support tool, able to support both the farmers and the relevant institutions towards the most appropriate technologies, choices and solutions. For these objectives, the evaluation of all these three scales of sustainability (economic, social and environmental) characterizing the farms, can be a valid support, through the construction of a single calculation tool, scientifically accurate and territorially validated, able to identify the links between them and to identify the strengths and weaknesses of the production system.
JEL: Q01; Q51; Q56.
Keywords: Sustainable Development; Sustainability indicators; Decision support tool.

Introduction
Constant innovation in the production techniques of the primary sector has contributed in recent decades to the exploitation - both good and bad - of agricultural systems and their resources. The intensification of production has led to important progress in the production systems needed to deal with the food demands of an increasing world population. On the other hand, it has also had a significant ecological and environmental impact on natural ecosystems. The sustainability of agricultural systems starts with this evaluation.
In 1987, the Brundtland Report was the first to describe "sustainable development" as "a development that meets the needs of the present without compromising the ability of future generations to satisfy their own needs".
In the literature, there are numerous definitions of "sustainable agriculture" (Hansen, 1995; Jacobs, 1995). It is thus necessary to distinguish between the different aspects of sustainability in relation to their aims: environmental, social and economic (Goodland, 1995). The important stages that have contributed to this awareness, such as the World Conference of Rio de Janeiro in 1992 and, more recently, the proclamation of the "Decade of Education for Sustainable Development" (DESD) 2005-2014 by UNESCO, have challenged the scientific community to establish techniques that combine adequate production with a more sustainable social and environmental impact. The application of indicators, defined as "synthetic variables of substitution of other variables that are otherwise difficult to determine" (Bockstaller et al., 1997), plays a prominent role in the

evaluation of sustainability standards both at decision-making and educational levels.

In agricultural areas characterized by intensive types of production, the need has emerged to establish what is still sustainable and what is not, in accordance with technological advances and new trends in agricultural markets: the differentiation of production, the use of low impact techniques, sustainable marketing techniques (shorter chains, certification tools) and new forms of income that can be integrated with traditional manufacturing processes.

Methodology

The method

The objective of this work was to construct a scientifically appropriate method for the assessment of the sustainability, technically applicable to different areas, through the evaluation of of farms in a local Italian context. This method will provide a support tool to farms (production, management and commercial decisions), local policy-makers (overview of the productions, creation of a database) and researchers towards innovative and more sustainable solutions.

The processed and aggregated data obtained are useful to assess sustainability levels in a given area, comparable with different production scenarios, both at a national and European level, and providing information on the real potential of policies to achieve the goals set by policy makers (Vos et al., 2000).

There are many different methodologies based on the scale of detail (field, farm or region), the objective of the work, the spatial and time scale, the resources available (human and economic), and the available data. It is possible to identify 3 main categories of approaches:

1) the use of individual indicators from different methods which can be used to focus on research aspects. On the other hand, these composite indicators lead to significant difficulties in finding the right combination of tools to achieve highly consistent final results (Gómez-Limón and Sanchez-Fernandez, 2010). They require a long time in terms of selection and collection of the necessary data;
2) the use of models (simulations) ensures a high accuracy of results through the use of a single methodology for different aspects of sustainability, but they are often complex (Castoldi et al., 2009), and the success of the work greatly depends on the availability and quality of the data;
3) from a strictly practical point of view, the choice of indicators often include synthetic applications, which lead to studies that are fast and applicable to different and unrelated situations. Thus, the use of a single method established through individual already aggregated and balanced indicators may be a viable alternative to assess sustainability in its various aspects, using qualitative and quantitative data, which are easy to find and adaptable for different contexts (Castoldi and Bechini, 2006). However, the validity of these methods depends on the accuracy of the data, and it is often necessary to deal with the problems of poor specificity in terms of the indicators, especially with the complex aspects of environmental and economic sustainability.

We therefore needed to find a system that requires easily detectable data (or at least that allows, in the absence of these data, equally simple and rapid evaluations) in order to minimize the loss of time and resources (Bockstaller et al., 1997), to avoid method-

ological and practical problems (Bockstaller and Girardin, 2003) and to reach a standardized evaluation. This process needs to describe the agricultural conditions wherever a farm is located and whatever its size. Often decision-making involves multiple, and sometimes contradictory, ideas about what is more or less sustainable (Blinder et al., 2010). The issues arising underline the need to find a practical approach, in fact sustainability requires an openness to new concepts and reflections rather than at an attempt at an overall understanding (Thompson, 2007). Surveys were therefore carried out based on the IDEA method[1] (Vilain, 2008), which has been scientifically validated for a geographically defined context. Previous surveys carried out using IDEA (Zahm, 2003, Zahm et al., 2005, Cadilhon et al., 2006, Bockstaller et al., 2008, Zahm et al., 2009) provide important information on the degree of sustainability of farms with different productive systems, sizes, degrees of specialization and multi-functionality. In this way, we can compare and evaluate the most innovative technological solutions, thereby gaining knowledge on the most modern production systems. IDEA does not monitor or verify the real situation of farms, but is used as a diagnostic and support tool for entrepreneurial decisions (Briquel et al., 2001) and during the evaluation and monitoring of the agri-environmental Measures of the Rural Development Program, as a decision-making tool, providing practical knowledge for funding opportunities (Zahm et al., 2005).
The method compares farms on the basis of quantitative indicators, assessing the strengths and weaknesses of the production system, and identifying possible ways to improve the level of sustainability.
Operationally, the method is based on: (i) calculations (e.g. nitrogen balance, stocking rate, economic indexes), measurements (e.g. number of animal and vegetal species, pesticides distributed) and evaluations (e.g. quality of work, animal welfare); (ii) these data produce results that determine the sub-indicators (indexed scoring scales that characterize the single data or a small group of data that characterize a single aspect); (iii) an additive sum of the sub-indicators forms the single indicators, applying a maximum and a minimum (0) score, weighted considering their importance; (iv) in the same way, a sum of the indicators produces a range of possible scores of the components (v) and the three scales of sustainability (Table 1, 2 and 3).
The calculation of many indicators (formed by sub-indicators) is rather simple, as only attribution of tabular scores is needed (for example the assessment of biodiversity or the quality of the landscape). Others involve processes that require a large volume of data (such as the evaluation of the use of energy, fertilizers and pesticides) and other cases are more complex (as in some economic indicators, which are based on the calculation of the indices of profitability and efficiency, such as ROE and ROI).
When focusing on the area of interest, an evaluation of the results can be carried out by considering individual indicators, otherwise their aggregation occurs by summing the individual scores to obtain the result of the components.
Since its inception, IDEA has evolved with new farming practices and has also undergone important changes and adjustments which have contributed to the better strength and weight of many of its indicators.

1. IDEA, "Indicateurs de Durabilité des Exploitation Agricoles" or rather "Indicators of sustainable of the agricultural exploitation", was developed on the request of the General Directorate of teaching and research of the French Ministry of Agriculture and Fisheries.

COMPONENT	INDICATOR		SCORES
1_Biodiversity	A1	Diversity of temporary crops	0-14
	A2	Diversity of permanent crops	0-14
	A3	Animal Diversity	14
	A4	Development and conservation of the species	0-6
2_Spaces management	A5	Crop Rotation	0-8
	A6	Size of plots	0-6
	A7	Management of organic matter	0-5
	A8	Buffer zones	0-12
	A9	Environmental Safeguard	0-4
	A10	Stocking rate	0-5
	A11	Management of forage areas	0-3
3_Agricultural practices	A12	Fertilization	0-8
	A13	Management of livestock effluents	0-3
	A14	Pesticides	0-13
	A15	Veterinary treatments	0-3
	A16	Soil protection	0-5
	A17	Water management	0-4
	A18	Use of the energy	0-10

Table 1. Agro-ecological Sustainability: Components and Indicators.

However, since it was originally designed with reference to the different environmental, economic and political characteristics of the French agricultural system, adaptations were made to account for the local context. Changes were made to the sub-indicators, modifying some range of possible scores or even replacing some of them (such as those that focus on aspects of agriculture in mountains or hill areas) with others deemed more appropriate considering the local area where the analysis was carried out. In effect, while not focusing on a particular geographical area or production, these methods are of course designed with reference to the local contexts in which they originated (Galan et al., 2007). In addition, we were able to adapt several indicators to make them valid for a heterogeneous variety of contexts. A modelling of the method was required, in order to create a tool capable of evaluating any type of farm categorized by type of production and exclude aspects that do not involve the farm.

COMPONENT	INDICATOR		SCORES
4_Quality of products and the territory	B1	High quality brands	0-10
	B2	Development of rural landscape	0-8
	B3	Management of non-organic wastes	0-5
	B4	Access to spaces	0-5
	B5	Social implications	0-6
5_Work and services	B6	Development of short chain	0-7
	B7	Autonomy and exploitation of local resources	0-10
	B8	Multifunctionality	0-5
	B9	Contribution to employment	0-6
	B10	Cooperative work	0-5
	B11	Future prospects	0-3
6_Ethics and human development	B12	Contribution to the balance and sustainable management of resources	0-10
	B13	Animal Welfare	0-3
	B14	Education	0-6
	B15	Work	0-7
	B16	Quality of life	0-6
	B17	Isolation	0-3
	B18	Hygiene and safety	0-4

Table 2. Socio-territorial Sustainability: Components and Indicators.

COMPONENT	INDICATOR		SCORES
7_Profitability	C1	Viability	0-20
	C2	Economic specialization	0-10
8_Independence	C3	Financial autonomy	0-15
	C4	Dependency from PAC aid	0-10
9_Efficiency	C6	Efficiency of the production process	0-25

Table 3. Economic Sustainability: Components and Indicators.

The survey

For a farm analysis, it is advantageous to operate in a sufficiently large spatial context characterized by a good variety of production types, but also reasonably confined to homogeneous social and economic sectors.

Our case study was an agricultural park, named *Parco Agricolo Sud Milano* (PASM), which covers more than 40,000 hectares in the province of Milan (northern Italy), whose characteristics fit the considerations described above. The farms in the park have a very different production, economic and environmental systems and sizes, which is a necessary prerogative for the sustainability indicators in order to assess the level of specialization, multidisciplinarity, and production differentiation (Pirani et al., 1992).

Although the PASM, like agricultural areas in northern Italy, is completely flat and farming is extremely intensive using advanced technologies, it nevertheless has characteristics that are not common to the entire Padana plain. In fact, the geographical location is classified by the regional administration as an urban area (*Revision no. 5 of the RPD of Lombardy published on 29-03-2011*). It has a high population density and attributes typical of peri-urban areas, such as fragmentation, competition from other important industries and the high economic value of the land. On the other hand, this territory also play an important social and ecological function and meet the requirements of towns located near a rural environment (Gaviglio et al., 2006). These characteristics here bind even more farms, especially if multisectoral, with the urban context in which they are located. This helps to increase the environmental and social multifunctions of the agriculture.

The first step in the research was the study of the farms in the park, using the databases available through the local institutions that contain their characteristics. Due to the large number of farms in the park (about 1000), it was thus necessary to sample a limited number of farms. Considering the type of production, the economic dimension and the geographical location (by splitting the the park into 4 production areas[2]), we selected 50 representative farms on which the analysis was conducted. We created a database to collect the data necessary to calculate the indicators. The requested information involved: (i) the database of the Lombardy region SIARL (farm size, crops, livestock, agricultural machinery, farm personnel, PAC contributions); (ii) interviews with farm personnel using a questionnaire (economic data, use of fertilizers and pesticides, other social and local area data); since the reliability of the farmers' responses is a limiting factor (Briquel et al., 2001), (iii) we also used estimates, observations and tabulated data (RICA).

Results

The method, with necessary changes, was particularly suited to the PASM. In fact, IDEA is characterized by a high degree of sensitivity to differences in the production and management of farms, and was used to highlight the strengths and weaknesses of many large-scale farms, but also of small farms in peri-urban areas in the Milan hinterland.

To facilitate the evaluation of the results, the categories of farms were stratified with the same criteria used for the sampling. The interpretations can be many: size, type of production, localization, etc.

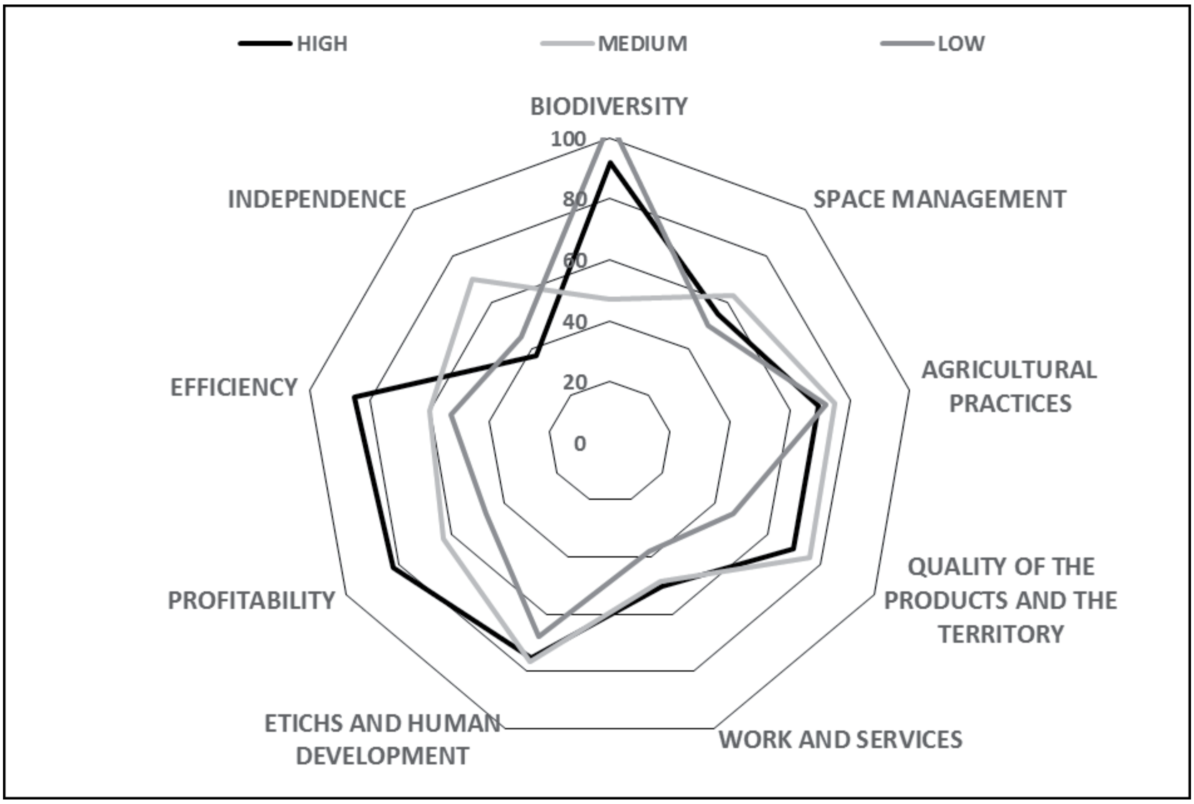
The agro-ecological indicators achieve higher results in contexts characterized by a high level of plant and animal biodiversity, by a virtuous space management, a high land-

2. Sector 1: North-West area, Sector 2: South-West area, Sector 3: South-East area, Sector 4: North-East area.

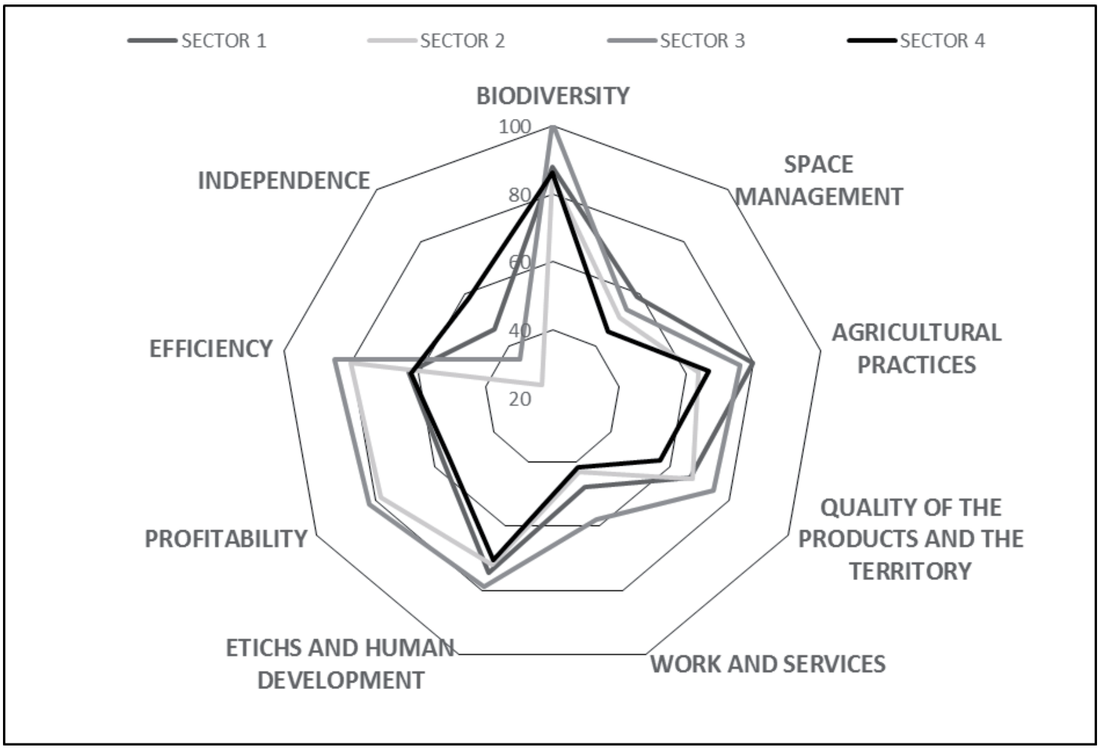
scape quality, as well as the rational use of energy resources, pesticides and fertilizers. Thus organic farms get particularly excellent ecological results, due to the non-use of chemical inputs. However, the approach used here raises some important questions regarding the compromises, which are considered necessary for an environmental evaluation, including obviously different inputs, in view of the diversity of the role and the objectives of conventional and organic production systems (Rigby et al., 2001).

Different ways comparing the results are possible which, when standardized and represented with a spider graph, provide a preliminary integrated characterization of sustainability (Girardin et al., 2000): (i) between 2 or more farms; (ii) between the results of the same farm over 2 or more years (iii) between farms aggregated for similar economic, productive or geographical characteristics.

In this case (Graphic 1) we aggregated the results of the sampled farms according to the related U.D.E. (Unità di Dimensione Economica: Unit of Economy Size) values (source SIARL).



Graphic 1. Results of the farms with a high (>100), medium (from 50 to 100) and low (<50) value of UDE.



Graphic 2. Results of the farms located in four different sectors of the Park.

The three classes highlighted important differences between the social and economic components. In general, medium-large farms have higher rates of the social components. In these cases, their results are in fact better in working conditions, animal welfare and the quality of products (often thanks to certifications and quality brands). The economic components have the same trends: large farms with a high number of animals (dairy and beef cattle, pigs and poultry), and the large rice farms located at the south edge of the park perform better in profitability and efficiency.

Even the agro-ecological components have a similar trend, however we noticed that their value is highly linked to the type of production. In this case, the organic productions (thanks to the more sustainable farming practices) and those with a wide variety of production and related activities (favoured by high biodiversity and a better organization of space) have clear higher values. The economic component named "Independence", linked to the weight of the subsidies on farm income, is notoriously dependent on the type of production (here particularly referring to the importance of the PAC aids in the rice production).

In a second approach, we classified the farms considering their location in the four sectors identified during the sampling phase (Graphic 2).

In this case we noticed a better performance

in the social component of farms located in sector 3 (which includes the city of Milan), characterized by the presence of a large number of multifunctional farms, with important agri-tourism activities.
The strong connection of the component of "Independence" with the type of production is even clearer here: the low value of sector 2, which is characterized by significant rice productions, confirms the high importance of the PAC aids. This sector and sector 3 have the highest values in economic indicators.

Conclusions

The method proved to be a valuable tool for assessing sustainability. The model was evaluated, selected and edited according to recent European policies, integrating agricultural production with environmental protection. The results highlight the need to now link these assessments with the income prospects of the farms provided by, European, regional and local institutions (the establishment PASM).
However, we identified a number of critical issues, principally due to:

- the low significance of some indicators linked to complex aspects of the environment and economic sustainability. Thus, considering the high malleability of the method, we attempted to improve it through the introduction of more specific parameters (even with more costly and time data);
- we often had to balance some indicators that we believed should have more or less importance in relation to our local context;
- the additive aggregation of the sub-indicators, indicators and components highlights the limitations of the results. The decision to remove the capping of scores ensured a better performance; however, we aim to adopt solutions that will achieve a more homogeneous aggregate score;
- the use of IDEA highlighted the need for standardized parameters and especially more objective evaluations of components such as labour, animal welfare, and environmental and landscape quality. Even the use of renewable energy sources and the use of energy saving systems, may be further evaluated in the calculation of agro-ecological sustainability and, consequently, if virtuous, the financial losses. In this case, "unsustainable" indicators can be applied to assess the sustainability itself, not as a goal, but as the process itself, or to provide information regarding the risks or the potential effects of actions or any negative impact (Smith, McDonald, 1998).

The PASM, founded more than 20 years ago, is one of the first cases of territorial institution for the protection of peri-urban agricultural areas. In these years, the territory and the economic situation have undergone changes and the institution needs to be able to take advantage of the opportunity of the interest of the citizens of Milan for the nearby rural areas. The results highlight the relevant role in the peri-urban areas of both large and small farms.
Small farms need of leaving the old patterns of production to cope the competition of larger farms, economically and technologically competitive, diversifying the production, the marketing, the buyers and the secondary activities (agritourism, school farm, restaurant, etc.), promoting the creation of new mechanisms of short chains, civic food networks, on-line sales and cooperation.
The large conventional farms need of protection because of their high economic importance and their role against the increasing

fragmentation and edification of the territory. Given the location of the PASM, a fourth scale was needed when calculating the overall sustainability of a farm, with the focus on institutions and decision-makers in general. Many of the choices that affect the three scales described so far also depend on the political, legal and bureaucratic context in which farms operate. This type of scale, called *Governance* (FAO, 2013) aims to assess the degree of evolution of the relationship between farms and decision-makers, i.e. information on technologies, streamlined bureaucracy and knowledge of regulations. We were therefore able to catalyze the path of a farm to sustainability through new technological choices and management (fewer chemical inputs, the use of renewable resources, new marketing systems, etc.).

We thus seek to grasp the aspects related to consumers, through marketing analyses, trends of production and consumption in order to create a match with those obtained from the supply side.

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